

# ~Roof Top Permaculture~

Transformation of the Inner City Environment



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## ~Introduction~

Many cities have a lot of 'lost', left over space; that is space which exists without consideration. It is the space between buildings, the roof tops, the median strips and the awkward street corners. These spaces in the city often become rubbish magnets or stray car parks. They are ugly, un-productive, un-loved and possibly dangerous.

It is these neglected areas of the city which this piece of writing examines. The objective is to establish ways in which these spaces can be rehabilitated to make a positive contribution to the city environment. The original intention was to investigate the whole range of types of lost space, but it quickly became obvious that this was not feasible within the given time limits. It was therefore decided to focus for the mean time on just one type of lost space; the roof top.

This analysis of the roof top as an area for the development of permaculture design, was chosen particularly as an investigation of how roof tops effectively become a building's fifth elevation. Roof tops often viewed from above in a city (Wellington in particular), with multilevel buildings, but rarely given the same amount of consideration as the other four conventional elevations. Roof tops in some cases are out of mind but not out of sight, becoming an unsightly and unlovely yet very dominant part of the city experience. The notion explored here is that these areas could become a very positive asset to a city if they were covered in vegetation.

In carrying out this investigation it quickly became apparent that many different approaches to creating 'garden' roof tops were possible. Each building in the city could have it's own unique garden place, which could only add to its special identity and become the delight of building users and the community at large. The report therefore does not seek to design a roof garden but rather explain the range of possibilities which exist in this context.

It is considered for reasons explained in this report, that one successful approach to the creation of such roof gardens would involve permaculture methods. 'Permaculture' is about an attitude to the land and living, which seeks to work with nature and natural systems to achieve a balanced harmonious ecosystem, within which humans exist as part of a larger network of co-operating life.

The report explains in more detail what permaculture is, both from a theoretical and practical viewpoint. It continues by explaining what some of the benefits of roof top permaculture could be, and considers some of the technical issues involved.

A site typical of an unused roof top area has been looked at in depth. A number of generic approaches have been established and suitable responses derived, but in all cases they are intended only as a useful starting point in the creation of unique and appropriate designs for particular locations, client needs and desires. Four very different scenarios are explored to indicate the range of different approaches possible for this situation, but an actual garden might in fact be a hybrid of these ideas or something with a totally different starting point altogether. These ideas are intended to stimulate interest and indicate a range of possibilities rather than to make any claim to be a comprehensive cataloguing of the possibilities inherent in any situation.

The four ideas investigated are:

- A garden for the production of food for humans**  
helping to introduce the idea of urban food production to the city
- A garden for people sensitive to allergies**  
an environment where all can enjoy the benefits of the garden
- A garden for the well being of the human mind**  
a kind of sanctuary from the stress of inner city living
- A garden for the preservation and the regeneration of habitat**  
for native plant, bird and animal species, encouraging a more diverse and stable ecosystem for the inner city

After preliminary conversations with some of the people within the Wellington City Council who make the decisions about which plants are planted where, the beginnings of a list of plants that may be useful for the Wellington region has compiled, and could also be applied to other places with similar climates. These lists are included at the end of each section about a specific type of garden in the printed report but are not included in the internet version.



## CHAPTER ONE

### ~What is Permaculture?<sup>1</sup>~

*'Permaculture design is a system of assembling conceptual, material, and strategic components in a pattern which functions to benefit life in all its forms.'*<sup>2</sup>

-Bill Mollison

'Permaculture' is a term coined by Bill Mollison, an Australian in 1978, describing a system based on working with nature and in effect mimicking natural ecosystems, to create 'sustainable' human agricultures, or '*perma-nent agri-culture*'. Since then it has developed into a much more holistic total lifestyle philosophy. It encompasses the concept of integration of people and landscape in a harmonious way which is beneficial and symbiotic for all life on the planet and the earth itself.

Working with nature as an ideal, is based on '*thoughtful observation rather than protracted and thoughtless action*'.<sup>3</sup> This is centered around the idea of respect for the greater ecosystem in which human life is but a small part. Elements in the environment, such as humans, plants, animals, water-ways, and soil, are seen from the point of view of all their functions and needs rather than just the yield they produce for human use. This allows integrated designs to evolve where different elements support each other within the design to achieve a co-operative balance.

Graham Bell sums up the basis of design on natural systems to try to achieve a way of living that goes beyond current agricultural practices:

*'... A forest is a system... that functions in five dimensions: the two horizontal dimensions, the vertical dimension, and the added dimension of time, its crowning glory being the fifth dimension of relationships. Each of the 'directions' maximises spatial use, adding to the productivity of the whole.'*<sup>4</sup>

The idea of permaculture is based not on rigid sets of rules but broad underlying values or codes of behavior. Mollison summarises<sup>5</sup> the main ethical basis of permaculture as:

#### 1. CARE OF THE EARTH:

Provision for all life systems to continue and multiply

#### 2. CARE FOR PEOPLE:

Provision for people to access those resources necessary to their existence.

#### 3. SETTING LIMITS TO POPULATION AND CONSUMPTION:

By governing our own needs, we can set resources aside to further the above principles.

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<sup>1</sup>For the purpose of this report only a brief summery of the main points of permaculture is given. There are many books available that give a more thorough introduction to the concept.

<sup>2</sup>Mollison, Bill. 'Permaculture A Designer's Manual', page ix

<sup>3</sup>Mollison, Bill. 'Permaculture A Designer's Manual', page ix

<sup>4</sup>Bell, Graham. 'The Permaculture Garden', page 5

<sup>5</sup>In his 'Permaculture, A Designer's Manual'

Distributing surplus and general principles of co-operation are also paramount to permaculture design.

*'Co-operation, not competition, is the very basis of existing life systems and of future survival.'*<sup>6</sup>

-Bill Mollison

The idea is that by people co-operating with each other in the areas of work, communication and economics, information and ideas can be shared so that everyone can learn to live in a more sustainable way.

With this sharing, greater efficiencies could be achieved freeing up land for non-controlled ecosystems and re-vegetation, which is also an important part of permaculture design.

The 'regenerative' aspects of permaculture seek to go beyond 'conservation' to allow global environments to grow back to a more stable state rather than to simply halt all future destruction.

In conclusion, permaculture is a way of thinking about situations thoughtfully, and instigating action, to create a balanced harmonious way for people to live in an integrated eco-system.

#### ~Permaculture in New Zealand~

In 1998 there were about a dozen people in New Zealand who held diplomas in permaculture that were active in consultancy and design<sup>7</sup>. The Permaculture Institute of New Zealand or 'PINZ' is the body distributing and coordinating information. It is organised into 'bioregions' around New Zealand, with a local contact person. This means most information from PINZ comes from a local level. PINZ can be contacted via:

PO Box 56-107  
Dominion Road  
Auckland.  
Ph (09) 372 6779.  
[pinz@earthcare.org.nz](mailto:pinz@earthcare.org.nz)

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<sup>6</sup>Mollison, Bill. 'Permaculture A Designer's Manual', page 2

<sup>7</sup>Kettle, David and Betsy, 'What is Permaculture?', Soil and Health, May 1998. page 26

## **CHAPTER TWO**

### **~Roof Top Permaculture~**

In this chapter, the benefits of roof top permaculture are explored, an example site for possible further development is examined, and methods for beginning a permaculture design are looked into.

#### **~Benefits Universal to Roof Top Gardens~**

Because the focus of this report is on roof top gardens as a method of inner city permaculture, the specific benefits of roof top gardening have been considered.

#### **International Reputation of Cities**

-A city employing systems of roof top permaculture would gain the international reputation of being an environmentally leading city, and tourism could increase, due to the novelty factor involved with the idea of roof top gardening. Such a city could also be an example to other cities and become a centre for learning, and research into the area of roof top permaculture in an inner city context.

#### **Human Well being**

-The psychological effects of more garden and nature zones are certainly very positive and a huge benefit for the citizens of the city.

-Added vegetation would be seen by many to be making the city more beautiful and a more pleasant environment to be in. Many views would be enhanced with the addition of roof gardens, due to the three dimensional nature of the city where many bare rooftops can be seen from higher vantage points on the hills and from other buildings.

-Vegetation reduces cold hard shadows and glare of some buildings, making the city environment more comfortable for the eye. The increased amounts of plant life can be seen as a joy and delight in themselves.

#### **Eco System Diversity**

-Animals and insects are provided with more habitat, encouraging a more diverse and therefore perhaps more stable eco-system in the city.

#### **Air Quality**

- Through photosynthesis, plants take in carbon dioxide and carbon monoxide and give off oxygen.<sup>84</sup> Increased biomass in the city may lead to increased oxygen levels in the air and decreased amounts of carbon dioxide from cars and other pollution sources.

-Dust and air borne particles will be cut down because, through evapo-transpiration, plants filter out hydrocarbons and sulphur (among other things), effectively cleaning the surrounding air. This may also help people with dust allergies due to the more purified air.

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<sup>84</sup> Studies have shown that one hundred and fifty square meters of 'plant surface area' (area of roof x height of the plant x surface area of the leaves and stem) produces enough oxygen for one person for twenty-four hours. - Kuhn, Monica, 'Blooming Rooftops' Permaculture International Journal June 1997, page 24.



### **Water Retention**

-The roots of plants absorb and retain water, reducing storm water runoff at peak times (making run off cleaner at the same), thus reducing loads on the city's storm sewerage systems. In Germany the government reduces drainage and sewerage rates for the owners of buildings with roof gardens, as an incentive.<sup>9</sup>

### **Increased Life of the Roofing Membrane**

-A layer of soil moderates extreme temperature swings experienced on the roof between day and night, and therefore the expansion and contraction of the roof will be moderated, and the life span of the roof will be increased. In England it has been recorded that:

*'The effect of temperature regulation .... can reduce roof temperatures by 40 C° in summer, and raise winter temperatures from -20 C° to -5 C°.'*<sup>10</sup>

-Because the roofing is covered, it is protected from harmful UV rays and conventional everyday wear and tear. Exposed flat roofs may require renewal after as little as ten years. There are documented examples of roofs under roof top gardens being in near perfect condition after fifty years and longer.<sup>11</sup>

### **Cooling and Insulation**

-In summer in particular, the soil layer on the roof top absorbs the heat during the day. During the night dew forms, and on the next day this dew evaporates to provide cooling, thus keeping the interior of the building cooler. This could keep residents or workers more comfortable and perhaps save energy in the form of air conditioning.

-The insulation value of soil, especially when wet is small however and should not be included in U-value calculations of the roof.<sup>12</sup> However a roof top garden may make an excellent cover for an inverted membrane roof.

### **Energy Cycling<sup>13</sup>**

-By putting food or plant scraps that came from the garden, back into the same garden, all of the energy that it took to grow the food or plants is kept within the area to assist with the growing of the next generation of plants. The introduction of roof top permaculture creates a use for some of the city's organic waste through composting, thus reducing landfill loads.

### **Economics**

-Economically, 'any amenity such as a roof garden could easily add up to twenty percent value to a domestic property...' which would also be true perhaps of commercial property. A

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<sup>9</sup> Cadji, Miriam, 'The Only Way is Up', RIBA Journal, August 1997, page 69

<sup>10</sup> Cadji, Miriam, 'The Only Way is Up', RIBA Journal, August 1997.

<sup>11</sup> Derry and Tom's roof garden in London. Landscape Design September 1992.

<sup>12</sup> 'U-value' is how insulation levels are measured.

<sup>13</sup> This idea is expanded upon in the section 'Beginning the permaculture design'



roof garden would also cut down on maintenance costs for the roof due to the increase in life of the roofing membrane. Air conditioning costs may also drop in summer due to the cooling effects of a roof top garden on the rest of the building.

#### **Location and Tenure**

-The relative nearness of roof gardens is a major advantage. Individuals or businesses cultivating their roof space do not have to make trips to and from allotments or other gardens, which saves time and energy (both human and transport).

-One of the problems associated with urban agriculture is the lack of tenure. Temporary garden plots are often displaced by what is viewed as more productive use of the land (such as car parks, bypasses<sup>14</sup>, apartments etc.) Many gardens are labour intensive to set up and people may be reluctant to invest time in an area of which continued availability is not assured. Roof top gardens are not likely to face this dilemma and therefore offer greater security of tenure.

-A roof top obviously has limited access and so the threat of theft and vandalism which may occur at ground level is reduced.

-Rooves are almost always in close proximity to a water supply as opposed to undeveloped areas where a garden might be feasible. They have the added advantage of being able to exploit rainwater collection from the roof (which some people see as being more appropriate in the use of crop production as opposed to the use of potable water from the municipal supply).<sup>15</sup>

-Most rooves<sup>16</sup> do not fall in the shadow of the buildings they cover and so often have excellent exposure to the sunlight.

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<sup>14</sup> Kensington Community Garden and Tonks Ave Community Garden are for example in the direct route of the proposed Wellington City bypass.

<sup>15</sup> St. Lawrence, Joseph, 'Urban Agriculture: The Potential of Roof Top Gardening'  
[www.cityfarmer.org/roofthesis](http://www.cityfarmer.org/roofthesis)

<sup>16</sup> Each site must be considered as an individual. The relationships between other buildings, aspect and nature of the roof top all determine microclimate.

### ~The Example Site~

The roof top I have chosen to use as a roof garden exemplar is one of the outdoor roof terrace areas of the Municipal Building (the Old Town Hall), where the Wellington City Council is currently housed. It is currently an unused, barren area. The roof area is accessed from the forth floor offices.

It measures approximately 7000mm by 13000mm and faces to the northeast, getting good sun all day. This aspect also means that minimal shading occurs from the actual building itself, which continues up past the level of the roof top area in question. The surrounding buildings in Civic Square do not seem to shade the site for much of the day.



Figure 1: Example site (the area on top of the part of the building that juts out on the right) as seen from Civic Square. Wellington, New Zealand.

Safety rails are already in place. Access from the ground level in terms of lifting materials up onto the roof could be from Civic Square, thus eliminating the problem of traffic control if a crane was to be used to bring materials on the roof top.



Figure 2: Existing roof top site, - note drain pipe in corner.

According to the plans and information gathered from the Wellington City Archives, the roof top area is formed by reinforced concrete with a painted grey finish. Drainage already exists at two ends of the area with a down pipe located on the eastern facing corner closest to the interior of Civic Square.

Loading has been approximately worked out by John Storey of the Victoria School of Architecture with regards to the size and placement of the supporting beams and columns and the materials and reinforcing used. In short, each storey below the roof top area is constructed in an identical way. This implies that the area I am focusing on, which is intended for human recreational use, could hold an additional storey of weight on it, which is adequate for a roof top garden using suitable depths of soil for the support of a wide range of species.



### ~Beginning the Permaculture Design<sup>1</sup>~

The idea of 'permaculture' is inherently a way of doing things based on a set of moral and ethical principles and therefore there is no set method of designing a specific environment.

In short the Permaculture garden is based on observation of nature and natural cycles.

*'The sustainable garden is modelled on nature. Nature works upon the basis of patterns in many dimensions; it is no accident that rivers curve, of that bees build honeycomb in hexagonals. Learning from observation of nature shows us that patterns are the way to build strong and enduring systems.'*<sup>18</sup>

- Graham Bell

A good place to start with the design of the permaculture garden is to analyse the site, in terms of its aspect and climate and the possibility of microclimate niches. The next stage may be to identify the resources available to make the project happen. These fall into a number of different categories:

#### **Physical resources**

-That is the actual site and its access to sun, water, soil etc. Note general access for humans.

#### **Human resources**

-How much human energy is available for the implementation and maintenance of the system?

#### **Economic / Material resources**

-The things already gathered or donated and the money that is available or that can be raised for the initial output cost of the garden.

The following diagram is an adaptation from Bill Mollison's 'Introduction to Permaculture'<sup>19</sup> and shows visually what goes into the design of a permaculture environment.

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<sup>17</sup>Because in this report the focus is on the exploration of roof top permaculture for the inner city area, there are unique criteria that apply and also because of the nature of the roof top environment, certain methods of permaculture design practice do not apply.

<sup>18</sup>Bell, Graham. 'The Permaculture Garden' page 23

<sup>19</sup>Page 2

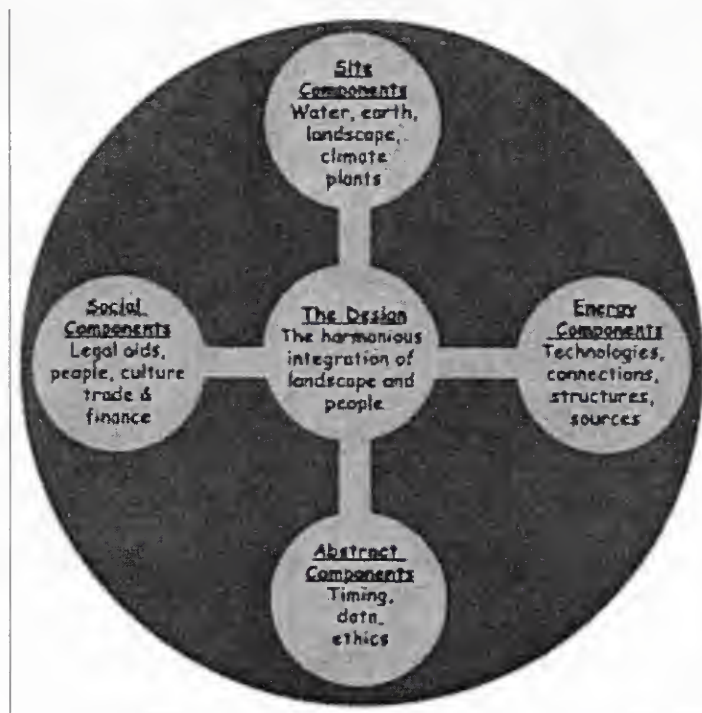


Figure 3: Elements of a total Permaculture design.

The following sections are principles to consider when designing the permaculture garden to create the beginnings of a diverse, healthy garden environment:

### Everything is Connected

The **relative location** of elements in permaculture design applies to any location of site and size of site. By designing for how elements are connected to each other, rather than seeing each feature of the design as a separate disconnected entity, sensible decisions can be made about where things go. Each element, whether it be a type of plant, a trellis, a seat, water, or the compost bin can be placed according to relationships with each other so that they assist each other.

*'It's not the water, or a chicken, or the tree. It is how the water, the chicken and the tree are connected .... Permaculture makes the connection, because as soon as you've got the connection you can feed the chicken from the tree.'*<sup>20</sup>

Bill Mollison

In order to do this it is helpful to analyse each element's basic characteristics; that is, it's needs and it's products. For example a hedge needs sunlight, water, soil nutrients, and possibly pruning. It could provide fruit, firewood, shade, privacy, be a windbreak and shelter birds and insects.<sup>21</sup>

Again Mollison writes:

*'The inputs needed by one element are supplied by other elements in the system; and the outputs needed by one element are used by other elements (including ourselves).'*<sup>22</sup>

<sup>20</sup>Mollison, Bill. 'Introduction to Permaculture' page 5

<sup>21</sup>Bell, Graham. 'The Permaculture Garden' page 32

<sup>22</sup>Mollison, Bill. 'Introduction to Permaculture' page 6

An illustration of this principle, applied to the example site of the municipal building in Wellington's Civic Square, could be the consideration of the placement of a compost bin:

**It's needs are:** organic material from humans (waste). Therefore it should not be too far away from where the source of the waste is, probably in this case from the interior of the building. It should be easily accessible so a *path* is needed. It also needs a relatively warm dark damp place, out of the direct sun and wind so it doesn't dry out and require extra water.

**It produces:** compost, so near to the intended sites of compost distribution would be a sensible place for it to go. Perhaps it could be near an *area for seedling growing* so a soil and nutrient source is created nearby to fulfil the needs of this area. It also sometimes produces smell, so not too close to *doorways* or *windows* and possible down wind of such openings. It has a solid form. This could be useful for growing things up it such as climbers making a kind of *multi - functional trellis system*.

So already a series of relationships has been established between the compost bin and a path, doorways and windows, a possible seedling area, and a trellis. This helps when making decisions about the placement of each element.

#### Efficient Energy Planning

Mostly when dealing with permaculture design, energy efficient planning means planning the area into 'zones' and 'sectors'.<sup>23</sup> This really is for larger scale areas and may not be entirely appropriate for a small roof top garden. The basic concept however is still relevant, with consideration of the placement of things being relative to how often the place is usually visited by humans.

For example, it may be better to have herbs near the entrance if that is the main thing that is collected from the garden. Plants like potatoes and broccoli may be further away because these beds are only visited infrequently.

#### Using Biological Resources

Part of permaculture is using biological resources. That is plants and animals to do the work wherever possible to save energy. When dealing specifically with the roof top garden, it may not be appropriate to apply many of the permaculture principles with regard to animals. There simply may not be the space, or the need for animals to be integrated into the system, except of course for those that come to the garden of their own accord such as birds and insects, which are of course very important,

Plants are chosen which work for the garden. The name given to plants with a particular ability to enrich the soil is 'dynamic accumulators'<sup>24</sup>. By using these plants the garden maintains its own ability to produce crops without the necessary addition of artificial

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<sup>23</sup>Mollison, Bill. 'Introduction to Permaculture' page 10. Gives a detailed account of the idea of zones and sectors.

<sup>24</sup>Bell, Graham, 'The Permaculture Garden' page 77



fertiliser.

Many of these types of plants are seen as 'weeds' but have a certain important job in the garden. They tend to be rich in minerals because their roots draw up nutrients from below which are released to improve the topsoil after their leaves fall off onto the soil. Many are also edible or medicinal and useful to other animals other than humans.

Plants which are nitrogen fixing can be used to keep the soil fertile. These can be inter-planted or used as borders around other plantings. All legumes are nitrogen fixing.

Certain plants may be planted specifically as 'green manure' crops that is, plants which are there to feed the soil. For example comfrey can be inter-planted with currant bushes. The comfrey is self-mulching when it dies, thus providing instant compost for the currant bushes, combined with suppression of unhelpful weeds.

*'Growing green manures for their own sake is advised whenever there would be a bare patch of ground in the garden.'*<sup>25</sup> - Graham Bell

### Energy Cycling

The growing of one's own food in a permaculture system, especially in the inner city, means the transport energy used to ship food from one source to another, is effectively eliminated, because the source becomes directly accessible. Packaging and marketing also disappears from the cycle of food growing to dinner plate.

Permaculture seeks to stop the flow of nutrients and energy away from a place and turn the flow instead into a cycle, so the energy created within a system in effect fuels the system as well.

An example of this is the use of kitchen scraps. If the scraps from a garden were simply thrown away, all of the energy used from the garden to grow that food is lost. If instead the scraps are put back into the system as compost for example, the energy created continues to be used in the same place. The same logic can be applied to grey water reticulation, although this may be difficult in some roof top areas.

If ways to collect and store the energy constantly coming onto the site are in place, less energy is needed from outside the system. Collected rainwater for use on the garden is an obvious example, - perfect for the roof top environment.

### Small - Scale Intensive Systems

Because permaculture is based on natural ways that plants grow without humans, gardens are more self-maintaining because all members of the garden work together.

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<sup>25</sup>Bell, Graham. 'The Permaculture Garden' page 63.

*'It is an essential hallmark of understanding that ecological damage is usually the result of human intervention. Doing as little as possible is the best way to help the environment. This is nowhere more true than in the garden.'*<sup>26</sup>

-Graham Bell

Part of permaculture is understanding how plants work together in 'guilds' so that plants benefit each other without human intervention. (A group of plants or animals that work well together is referred to as a 'guild'<sup>27</sup>).

The knowledge of guilds is also referred to as companion planting. This means making intelligent decisions about which plants are planted next to each other. These symbiotic relationships between species can be beneficial in a number of ways, including increased yields and helping to keep human maintenance levels to a minimum. A list of companion plants for some common garden plants is provided in the section entitled 'The Garden of Many Uses'

*'Two things get together, and they both do better as a result. The ideal marriage if you like; by marrying together plants in the garden we should be able to ensure a better harvest for less work.'*<sup>28</sup> - Graham Bell

A 'guild' usually is made of a group of plants and animals clustered around a central element. Some of the functions that plants within a guild may perform for the benefit of the central element are:

- Reducing root competition from weeds or unhelpful plants.
- Providing physical shelter from sun or wind burn or frost
- Providing nutrients
- Assisting in pest control

Some examples of these co-operating guilds are:

-**Marrows, radishes and marigolds.** Nice colour and beneficial insect attraction. Radishes mature before the marrows start thus avoiding bare soil ripe for unhelpful weeds.

-**Broad beans, apples, chervil and nasturtiums.** The ground cover of nasturtium keeps in the moisture needed by the beans and apples in the soil and attracts blackfly away from beans. Chervil attracts hoverflies which then eats the aphids on the food crop.

Certain companion plants stimulate surrounding plants also, and can be designed into any garden. For example camomile is reputed to improve plant vigour and perfume, to increase disease and pest resistance and help water stressed plants.<sup>29</sup>

Pests can be repelled, mystified and eaten by encouraged predators if the right companion plants are chosen. For example lavender bushes can repel some insects with its strong scent. This natural form of pest control helps eliminate the need for pesticides and other dangerous chemicals.

<sup>26</sup>Bell, Graham. 'The Permaculture Garden' page 63.

<sup>27</sup>Mollison, Bill. 'Introduction to Permaculture' page 25

<sup>28</sup>Bell, Graham. 'The Permaculture Garden' page 80

<sup>29</sup>Little, Brenda. 'Companion Planting in New Zealand' page 91.

One permaculture method for creating a co-operative low (human) maintenance garden, is to use a basic structure of perennial, biennial, self-seeding and self-mulching plants to reduce labour (because they don't have to be replanted every year), and increase environmental stability<sup>30</sup>. Because they occupy the same space for a long time perennials greatly aid soil fertility by maintaining an open soil structure with plenty of pore space and humus. Both of these help the soil retain water and air. The emphasis on perennials provides the more durable framework into which annuals can be fitted. Nearly all herbs and many edible wild plants are perennial.

#### Diversity

Permaculture teachers such as Bill Mollison, encourage an examination of the traditional methods of western garden which divides species into sections, often in straight rows.<sup>31</sup> By separating plants into artificial groupings rather than letting natural guilds evolve, extra work may be created with the elimination of more pests. Boundaries and clearly defined lines between vegetables, flowers and other plant types disappear.

*'To the observer, this may seem like a very unordered and untidy system; however, we should not confuse order and tidiness. Tidiness separates species and creates work .... whereas order integrates .... European gardens often extraordinarily tidy, result in functional disorder and low yield.'*<sup>32</sup>

Bill Mollison

By planting a range of species of plants rather than a monoculture, a greater variety of produce is available, and the whole system is more stable (if co-operative species are planted). The amount of produce from a monoculture may be larger than the amount from the same plant in a permaculture system, but a permaculture garden creates a wider range of *types* of yield and so the total 'sum of yields'<sup>33</sup> may in fact be higher. The idea of diversity within a permaculture garden is related to the number of beneficial relationships between elements rather than the actual number of different things within the area. This is where the idea of functional 'guilds' of plants applies.

#### Edge Effects and Flat Space

Gardens can be designed so that all available space is used, both in the vertical and horizontal direction, which is especially pertinent to a roof top environment where space may be at a premium.

One way to do this is to consider the edges of elements when designing. Graham Bell describes the principle by explaining that the study of ecology, which deals with how nature is made up of different species living together, emphasises that no one element stands alone. They (and humans are included too) all thrive by interdependence with neighbours.

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<sup>30</sup> Plants fall into three main categories: annuals (grow from seed, reseed and die in a single year), biennials (take two or three years to complete the same cycle), and perennials live for a number of years.

<sup>31</sup> Mollison, Bill. 'Introduction to Permaculture' page 24

<sup>32</sup> Mollison, Bill. 'Introduction to Permaculture' page 24

<sup>33</sup> Mollison, Bill. 'Introduction to Permaculture' page 25



*'The most fruitful places in nature are where different ecologies meet. This is because it is where there is the most opportunity for swapping energy usefully'*<sup>34</sup>  
Graham Bell.

This interlocking of elements and species creates in effect the strength of the system as a whole. Greater lengths of edge space can be created with small changes to the design, creating an interesting looking, diverse garden with increased output.

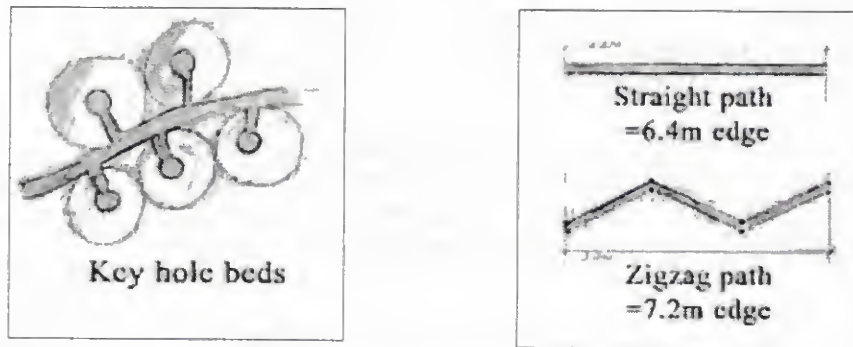


Figure 4: Examples of ways to increase edge lengths

A similar concept can be applied to the growing plane itself. If the growing beds are not left flat but are given a third dimension, more area is created within the same actual space. Consideration of water catchment during rain or watering may also be incorporated into the design.

For example:

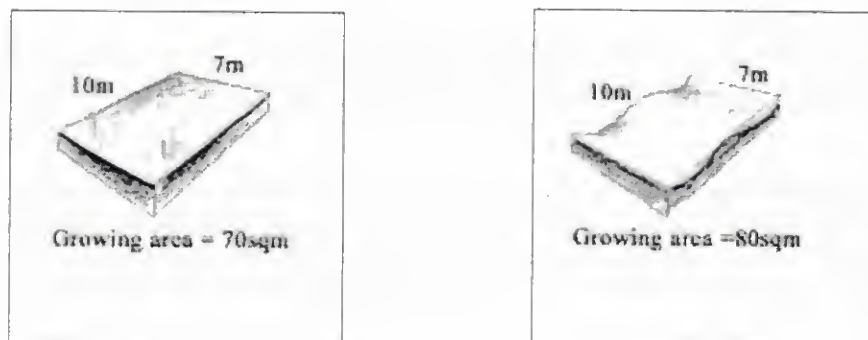


Figure 5: Increasing the growing plane area

A way to use space effectively in permaculture is to 'stack' plants. This happens above ground with the tallest plants forming a canopy, middle-sized plants forming the next vertical

<sup>34</sup>Bell, Graham. 'The Permaculture Garden' page 23

layer and grasses, herbs and ground covers occupying the ground plane. This allows each species to use all available resources such as light, water, space, nutrients etc. This same system occurs below ground with root depths and structures being suited to different conditions. This mimicking of natural forest systems means dense layering of plants prevents weed growth and makes maximum use of space and resources. Stacking plants effectively saves time, effort (and money).

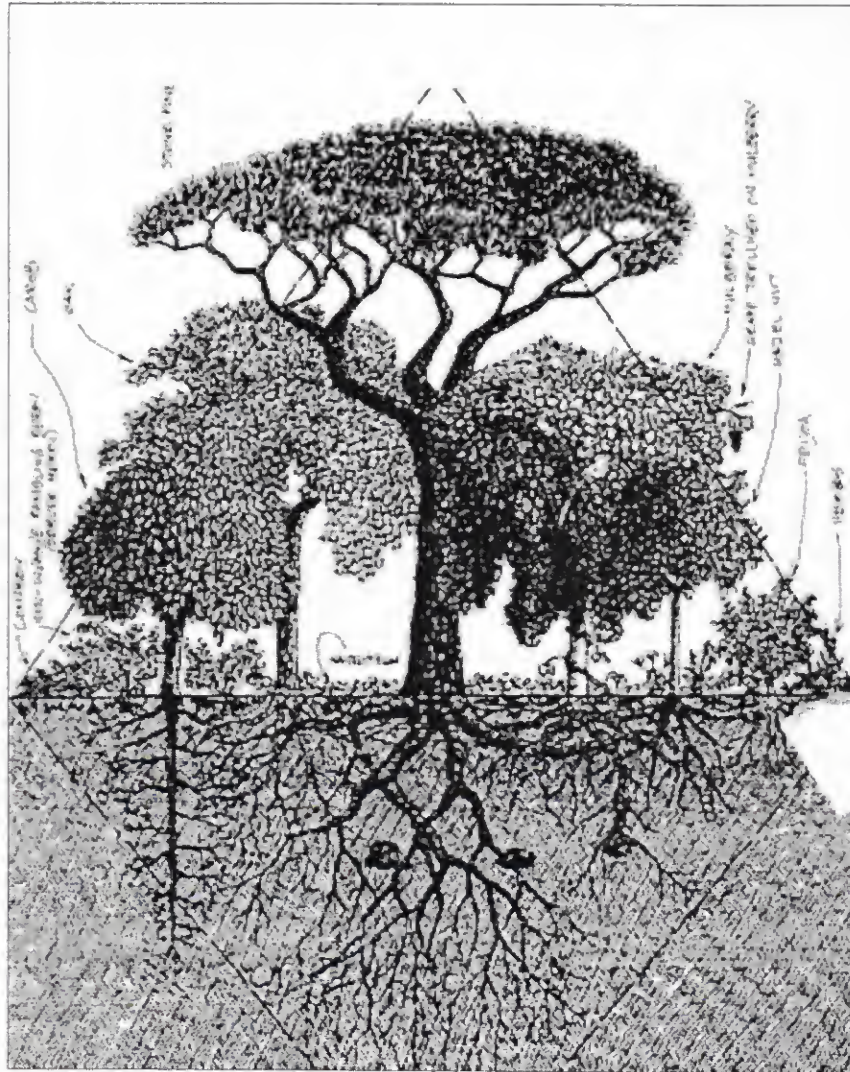


Figure 6: Plant stacking in rich soil and water environment, sharing light and nutrients in canopy, mid level, herb strata, and root levels.

This concept of stacking extends to time as well. If plants are selected so that yields are given in all seasons, the garden is useful all year round. The same principle is true for the planning of gardens in terms of yearly cycles. While trees and shrubs are young the surrounding soil can be used to grow quicker growing species, which support and shelter the young plants as well. As the trees and shrubs mature and get taller and spread out, the smaller plants become the under storey.



Walls are also a valuable growing plane, where climbers, vines and creepers can inhabit vertical space.

### People's Enjoyment

Lastly the factor of the input of the human work that is to be done in the garden can be taken into account so that it is an enjoyable, learning process for all.

*'Gardening is therapeutic. It can be carried out on your own ground, .... and is within your own power..... Because we retreat to the solace of our garden does not mean we are turning our backs on the world. Far from it. The healing action of working in the gardens makes us much better able to deal with the stresses of our daily lives.'*<sup>35</sup>

- Graham Bell.

Most of these principles are related to attitude and so become a more subjective thing. Mollison calls them 'attitudinal principles'.<sup>36</sup>

-Everything works both ways:

This basically deals with the way humans view things. A resource can be seen as an advantage or as a disadvantage, depending on what outcome is desired. For example, a roof top in the shade of another taller building may mean the area doesn't get enough sun to grow types of food crops. It also means however that a special microclimate has been created for the growing of shade loving plants like some types of native ferns.<sup>37</sup>

*'Disadvantages can be viewed as "problems" and we can take an energy - expensive approach to "get rid of the problem", or we can think of everything as being a positive resource: it is up to us to work out just how we can make use of it.'*<sup>38</sup>

- Bill Mollison

This is also the principle that encourages people to see old 'rubbish' as perhaps something useful. For example, old drums can be used as plant holders, forming a contained bed. This way of viewing things is not only environmental in terms of reusing discarded objects, but is also economical, if initial cost of creating the garden is considered. Perhaps such elements would be interesting visually and add to the delight of the garden as well.

-Permaculture is information and imagination – intensive:

In permaculture, the physical resources are used but also the human ability to use information learned in a sensible and thoughtful way is utilised. This makes the system (in terms of human input), information and imagination intensive rather than 'energy or capital - intensive'.<sup>39</sup>

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<sup>35</sup>Bell, Graham. 'The Permaculture Garden' page 16

<sup>36</sup>Mollison, Bill. 'Introduction to Permaculture' page 30

<sup>37</sup>Some types of native ferns don't require as much humidity as others and so are perfect for dry shady environments. For a suitable species see the 'native plant list'

<sup>38</sup>Mollison, Bill. 'Introduction to Permaculture' page 30

<sup>39</sup>Mollison, Bill. 'Introduction to Permaculture' page 30



*'Information is the most portable and flexible investment we can make in our lives; it represents the knowledge, experience, ideas, and experimentation of thousands of people before us... We can begin to think in terms of multi-disciplines, and to design systems which save energy and give us yields.'*<sup>40</sup>

Bill Mollison

There is no end point to a permaculture designed area, rather only the limits of ones' imagination as to how things could work better or be integrated into an already functioning system.



Figure 7: Relationship networks in the garden.

<sup>40</sup>Mollison, Bill. 'Introduction to Permaculture' page 30

## CHAPTER THREE

### ~The Garden's Focus~

*'To design anything consciously we must understand the importance it has in our lives. In gardening people often do what is fashionable rather than what would suit them best. There are some easy questions we can ask ourselves to make sure the garden works for us, rather than the other way round'*<sup>41</sup>

-Graham Bell

In this chapter some of the ways in which the focus of a permaculture garden can be shifted to reflect the needs of the intended users has been explored. Permaculture design is varied and can fit into any situation in terms of site and intention for the garden.

The chapter is organised into four different sections:

**- Urban Food Production - the 'Garden of Many Uses'**

A garden for the production of food for humans, helping to further introduce the idea of urban food production to cities.

**-Well Being in the Inner City Environment – a 'Sanctuary Above the Sky Line'**

A garden for the well being of the human mind, a kind of sanctuary from the stress of inner city living.

**-Human Physical Health in the City Environment - 'A Garden for People Sensitive to Allergies'**

An environment where all can enjoy the benefits of the garden.

**-Regeneration and habitat - 'A Native Garden Above the City'**

For our native plant, bird and animal species, encouraging a more diverse and stable ecosystem for the inner city.

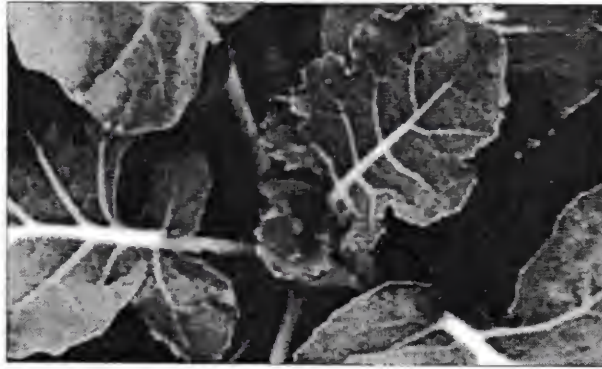
Each garden's attributes and its relevance in a permaculture context are explained in the beginning of each section. Brief plant listings are included at the end of each section with the intention of being a starting point for further research on the part of the grower, rather than as a comprehensive list detailing each plants needs in terms of microclimate.

While this chapter is broken into separate sections, a permaculture garden could be any combination of the ideas discussed or could be designed with a different focus altogether. Each permaculture garden has the potential to be a unique blend of the people's ideas involved in it's conception and maintenance, and will adjust and change over time as it is learnt which plants are best suited to the specific site.

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<sup>41</sup>Bell, Graham. 'The Permaculture Garden' page 9.

## ~Urban Food Production~



*'Permaculture aims to bring food production back to urban areas... It is only a matter of public persuasion and responsible decisions to re-direct these activities [the tending of ornamental city plantings] to useful species, in a multidimensional and multifaceted permaculture.'*<sup>42</sup> -Bill Mollison

Exploring the issue of urban food production to address problems with human cities associated with sustainability, is already a large part of the focus of this report, and has been discussed at length, particularly with its direct links to permaculture principles. In light of this, a section on a 'producing garden' has been included. This type of garden may be the most obvious response when designing with permaculture principles as a base.

Carol Venolia in her 'Healing Environments' of 1988 also describes another aspect to urban food production:

*'By growing our own food we begin to recall what many of us have forgotten: that we participate in a complex system of interdependent natural cycles.'*<sup>43</sup>

This garden is aimed at providing for some of the physical needs of humans available from the garden.

### **Air pollution in relation to food growing**

When discussing food production in the inner city, queries about the safety of food which may be contaminated, in particular by car pollution were raised. According to some research looking at the effects of air quality on plants carried out since 1968 by the Ontario Ministry of Environment and Energy<sup>44</sup>, most of the toxins collected by plants come from the soil rather

<sup>42</sup>Mollison, Bill. 'Introduction to Permaculture' page 171

<sup>43</sup>Venolia, Carol. 'Healing Environments' page 136

<sup>44</sup> Canadian research.



than the air.<sup>45</sup>

The amount of airborne lead which is the primary contaminant of concern, has according to the same sources dropped with the introduction of unleaded petrol<sup>46</sup>. Nearby industry or other point sources of emissions may be an issue to be considered however, if concerns are raised about contamination of produce from the air. A suggestion is to test food before consumption in the more densely polluted areas. Perhaps if these areas proved to be unsafe for food production, they could be used for the growth of non food producing plants such as natives or simply 'greened' as a way to help deal with the pollution<sup>47</sup>.

In terms of soil, one must be careful to ensure that lead based paint is not on the base for the garden. Even if soil is contaminated with lead, certain crops can still be grown safely.

Plants and lichens can also be used as indicators of high levels of air pollution by the way they become injured. A detailed account of this appears in:

*'Air Pollution Injury to Vegetation'* by Ibrahim Joseph Hindawi<sup>48</sup>

This is an old publication but still contains relevant information if areas were to be planted for the purpose of pollution detection.

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<sup>45</sup> St. Lawrence, Joseph, 'Urban Agriculture: The Potential of Rooftop Gardening' Chapter three, section 'Pollution'

<sup>46</sup>Hindawi, Ibrahim Joseph. 'Air Pollution Injury to Vegetation'.

<sup>47</sup>The pollution absorbing properties of plants is detailed in the section entitled 'Benefits of roof gardens'.

<sup>48</sup> Government Printing Office, U.S.A. 1970 – available in the Wellington Public Library

## ~The Garden of Many Uses ~

### Aim:

To design a roof top garden for the municipal building which produces products for humans in a way which encourages co-operation between different species through companion planting.<sup>49</sup> Chemicals should not be needed with careful selection of plants to perform tasks such as pest control.<sup>50</sup> A system of permaculture should be considered to make the most of the small plot in a harmonious way, beneficial obviously to humans but also to the animal life<sup>51</sup> of the garden and natural environment overall.

*'It is not the number of diverse things in a design which leads to stability, it is the number of beneficial connections between these components.'*

-Bill Mollison, 'Permaculture - A Designers' Manual'

Products which could be designed for are:

- Food: vegetables, fruit, herbs.
- Medicinal plants.
- Other useful things like craft materials, fuel etc.

Seasons should be considered so that different plants occupy the same space but different time niches. This means the garden will be producing all year round.

Growing areas for seedlings can be incorporated into the garden too to cut down on costs. This area can be as sophisticated as a green house or as basic as a simply fashioned cloche.

### Who is this garden for?

The garden is aimed at providing for some of the physical needs of humans. This particular example is primarily for the workers in the building and those who contribute to or tend the garden.

### Why use rooftops in this way?

It may become more important in the future to bring food production back into urban environments, as a response to pressure on rural lands to provide for large cities which produce none or little of their own food.

*'Most cities carry enough fuel and food for all their people for about three days. These resources ... are transformed into waste which then has to be exported from cities which would otherwise drown in their own waste'*

- Rosemary Morrow - 'Earth User's Guide to Permaculture.'

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<sup>49</sup>Details of this method appear in this section.

<sup>50</sup> For example sage and rosemary planted near carrots will protect the latter from the carrot rust fly.

<sup>51</sup>In this case mostly birds and insects only

Perhaps one way to begin addressing this issue is to start encouraging productive roof top gardens.<sup>52</sup> Organic waste and the nutrients it carries can be cycled back into the growing process by turning it into compost, which is valuable for a garden's fertility. Rainwater can be collected also.

By growing ones own food, a task which is hard for those who spend most of their time in the city and do not have land, the individual has more control over how that food is grown, which seeds it was grown from and the processing it went through before ending up as a food source. This is an important aspect if one considers issues like genetic engineering and pesticide residue to be important issues. This gives people more choice about the kinds of food they want to eat and having regained that control may be positive and empowering.

Closer sources of food on nearby roof tops could mean direct accessing of fresh produce. This would perhaps be more desirable in terms of eating healthy nutritious food which is fresh, than food which has had to travel for days over large distances to get into the city.

#### How could produce be distributed?<sup>53</sup>

There are many different ways to address this issue which work equally as well. Decisions like this would need to be made by all people involved and agreed upon by all for it to work. Food for free is a rapidly disappearing concept. I talked to the owner of a nursery about using fruit trees for street plantings. She said basically

*'That would never work, people would just take the fruit'.*

Perhaps the question could be asked, is there something wrong with that? Food from plantings could be seen as an incidental benefit as part of living in a community. It is a way to be self sustaining as an individual and also as a larger community.

If the plants were seen by everyone as community resources for the whole community, then perhaps they would be more inclined to look after them and not abuse them.

Here are a few suggestions as examples of food distribution systems:

- Plants in public spaces could be harvested as they ripen by individuals walking by, or could be collected by charity groups such, the Salvation Army, Food Banks or Food Not Bombs<sup>54</sup>, to be distributed through their networks.
- For a roof top garden: Some parts of the garden such as the herbs could be available for picking by anyone and could be free. There may need to be some limits put on the amount of produce individuals are allowed to take from the garden if people were taking more than their fair share. This would over time hopefully become unnecessary as people become used to a co-operative sharing situation.

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<sup>52</sup> There are many other opportunities for the using of wasted or lost space in the city apart from just roof tops.

<sup>53</sup> The issue of who would look after these gardens is an important one and because this is universal to all types of garden examined in this report there is a separate section entitled 'Maintenance' which addresses this specifically.

<sup>54</sup> Food Not Bombs is a group who collect food which would otherwise be thrown away and wasted from businesses around the city and turn it into a meal, free for anyone who needs or wants it. Wellington's Peace and Environment Center can be contacted for more details.



- Notice could be given of which parts of the garden are ready for harvesting so people knew what was available. Individuals would then simply access the garden when it was convenient for them, and using communal tools, help themselves. Although produce would be free, a koha<sup>55</sup> could be given by those using the garden to purchase tools and seeds where necessary.
- Nominated people could be in charge of the garden and when parts of it were harvested, could distribute the food to those who wanted it within the building. Left overs could be left in a public space within the building for people to help themselves. Koha may again apply.
- Produce could be sold at cost price<sup>56</sup> to employees / residents upon ordering what was in season at the time. If someone was keen, secondary products, like preserves could be made and sold from the garden. Personal ventures like this may be a way of generating some extra, local income.

#### What to grow?

Most of the common vegetables, herbs and even some of the fruit trees commonly found in food producing Wellington gardens could be integrated into a roof top garden design. Some of the more invasive rooting species' (such as fennel for example) introduction to the rooftop environment, should perhaps be carefully considered to avoid any possible damage to the water proofing layer and to the roof membrane itself. Such species may be grown in containers to solve possible problems.

Part of successful permaculture design is understanding how plants work together to either help or hinder each other's growth. This is commonly called companion planting.

*'The experiments necessary to turn it [allelopathy] into an exact science have not yet been made, but gardening has been going on for a long time and people aren't stupid. They notice things. They may not know why something happens but they usually register the happening.'*<sup>57</sup>

Comprehensive lists and resources relating to the New Zealand and Wellington specific region exist and are readily accessible.

As a further addition, Joseph St. Lawrence, who completed a master's degree in Environmental Studies<sup>58</sup>, based his thesis on roof top gardening in Canada. He recommends certain plant species as suitable for the roof top environment based on his practical research of roof top gardening. Most of his report is published on the Internet at the site:

[www.cityfarmer.org/rooftopthesis](http://www.cityfarmer.org/rooftopthesis)

posted by City Farmer, Canada's Office of Urban Agriculture. He grew his plants in shallow containers in an Ontario (Canada) spring and summer season. It is worth noting however his comments with regards to his findings:

*'It is important to note that my recommendations are for this site. Elsewhere, and*

<sup>55</sup> This term generally means a donation; giving as an act of love.

<sup>56</sup> This scheme does need to be about making profit. Cost price may be the cost of the seeds etc.

<sup>57</sup> Little, Brenda. 'Companion Planting in New Zealand' page 9.

<sup>58</sup> York University, North York, Ontario, Canada. 1996

*indeed in another season, it may be found that the problems I experienced do not materialise, or that the problems I did not encounter are significant. Advice should always be taken with a grain of salt.*<sup>59</sup>

### ~Well Being in The Inner City Environment~



The idea of 'well being' for the human mind may often be overlooked in the design of new structures and dwellings for the inner city environment. The introduction of systems of permaculture and the encouragement of roof gardens, is a way to allow for this crucial design aspect and perhaps more importantly it is a way to modify existing spaces and buildings so that they are more conducive to nurturing, healing environments for humans.

The increased well being and the healing aspects for humans could be seen as one of the major benefits of permaculture systems introduced to inner city Wellington. It is the intention of this section to elaborate on this area. The type of garden focussed on is one which could be a type of sanctuary for inner city workers and residents. This garden concentrates primarily on the well being of individuals or groups of workers or residents. The general mental health of the community as a whole could also be considered.

A cleaner, more beautiful, productive environment within the city, which every citizen can have a part in, may encourage pride and respect for the maintenance of that environment. If visible progress were made in a way that is tangible for people, perhaps citizens would feel that positive steps are being made in the direction of environmental responsibility, social interaction and even economic growth of the local community.

When dealing with the production of resources such as food, as part of a permaculture system, surpluses would naturally be shared among those who have less. This is a way to transcend economic boundaries and break economic cycles. Growing one's own food and having the knowledge to do so, is a form of self-determination, which can be seen as a positive thing for citizens.

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<sup>59</sup>This appears in the section entitled 'Revenues' in the chapter 'Observations'.

Gardening can be seen and is seen by many as therapeutic. The success of horticulture therapy<sup>60</sup> is a good example.

*'Some patients are difficult to reach and motivate. Working with plants may provide an impetus and initiate a response... One of the great advantages of gardening is that it is not a static activity. There is always something happening - a new sprout, shoot, or leaf is forming, a flower is opening or fading and has to be removed. Then the cycle begins all over again. Most important ... is a living thing depending on them for care and sustenance. This gives the patient the will to go on and an interest in the future.'*<sup>61</sup>

-Dr Howard A Rusk

This principle of positive interaction with plants for the sustenance of the human mind would also logically extend to the person with less severe problems.

*'Business people who have a collection of healthy, well groomed plants in their offices are usually calmer, more efficient, and easier to deal with than those who don't have plants or whose plants are neglected.'*<sup>62</sup>

-Elvin Mc Donald

The issue of education was touched on in the introduction. The sharing of the skills needed in the garden, is another way to tie together the community and the passing on of knowledge would perhaps be an exponential thing with each student being able to become the next teacher. This may also provide the opportunity for employment as well as greater community interaction and self-esteem.

An article called 'Growing Inspiration' by Michelle Lampis,<sup>63</sup> which details how an Australian organisation called 'Bondi Youth', which provides accommodation for homeless young people, undertook a permaculture project and experienced numerous unforeseen benefits to the area of well being for the individuals and the community. For example, neighbours were more willing to interact with the tenants, relationships were more relaxed and comfortable when outdoors in the garden, tenants became excited and enthusiastic about the project, seeing tangible results, and began:

*'To question their role in society and their ability to grow their own food and not rely on the nearest supermarket so much.'*<sup>64</sup>

These basic community building attributes may happen on a wider scale with the encouragement and realisation of more permaculture roof gardens and permaculture projects for any the inner city region.

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<sup>60</sup> 'Horticulture therapy is used in treating a wide range of physical and mental disabilities; people of every age, illness or therapeutic need can participate in some aspect of plant care' - Carol Venolia 'Healing Environments' page 132.

<sup>61</sup> Dr Howard A Rusk, Director of the Institute of Rehabilitation Medicine, New York. Source is Carol Venolia's 'Healing Environments' page 132.

<sup>62</sup> Venolia, Carol. 'Healing Environments' page 133.

<sup>63</sup> Permaculture International Journal, no. 71, June - August 1999.

<sup>64</sup> Lampis, Michelle. 'Growing Inspiration' Permaculture International Journal, no. 71, June - August 1999.



*'There's not a pair of legs so thin, there's not a head so thick,  
There's not a hand so weak and white, nor yet a heart so sick,  
But it can find some needful job, that's crying to be done  
For the Glory of the Garden glorifieth everyone'.*

-Rudyard Kipling (1911) The Glory of the Garden<sup>65</sup>

### ~A Sanctuary Above the Sky Line~

*'We may have to learn again the mystery of the garden:  
how its external characteristics model the heart itself,  
and how the soul is a garden enclosed, our own perpetual  
paradise where we can be refreshed and restored.'*

-Thomas Moore, 'The Re-enchantment of Everyday Life.'

#### Aim:

To design a garden for the purpose of well-being and sanctuary in the city. All of the senses could be engaged to create a healing, stimulating, rejuvenating, relaxing environment.

The provision of a place to sit quietly might also be an aspect to incorporate. Perhaps this area is shaded in the summer so it is as comfortable as possible.

#### Who is the garden for?

This is a garden for people. It is to act as a relaxing calm space for the inner city worker or resident. In this specific case of the municipal roof top garden (the example site), it is aimed at the office worker, improving working conditions by providing a place to relax on breaks, thus helping with stress levels. This garden addresses the nurturing of the human psyche.

#### Why plant roof tops in this way?

In the middle of the city it is easy to become detached from the natural world of vegetation and animal life. Carol Venolia discusses this notion:

*'In an urban environment, plants can reconnect us with the earth and life's cycles.'*<sup>66</sup>

A lot of people who dwell in the inner city have little or no opportunity to be in a garden space at all without travelling a relatively long way, which with current working hours and economic factors is difficult and inconvenient for many. Those who work in city offices spend most of the daylight hours in an artificial internal environment, with perhaps short breaks to venture outside. It is almost unimaginable to think one could find a quiet, shady private garden oasis in the central city to take refuge from the strains of city life.

*'Some enlightened corporations have found that gardens visible from work areas*

<sup>65</sup> Bell, Graham, 'The Permaculture Garden' pg 141.

<sup>66</sup> Venolia, Carol. 'Healing Environments' page 130

*improve employee moral and productivity.*<sup>67</sup>

A similar effect may filter down to pedestrian level where one could simply look up to the roof line and see living growing greenery above the city<sup>68</sup>.

#### **How could a sense of well being be achieved?**

A sense of well-being could be achieved by engaging the human senses within a space thus creating a harmonious, energy rich environment.

- Taste: Is there opportunity to experience this sense to provide direct links to the environment? A few herbs could be selected for planting so that they could be easily picked if desired<sup>69</sup>. Easily identified species with pleasant tastes are a good idea. Of course many edible plants could be included as part of a holistic design, from miniature fruit trees to vines bearing fruit.
- Touch: What can be felt through the hands the feet and the skin? What are the surfaces of the garden?
- Plants with scent could be considered to create pleasant aroma in the air. Can car fumes etc be smelt from nearby?
- Plants with bright colour, either flowers, fruits or leaves could be used to infuse the space with vibrancy. There are many ornamental plants that are still useful and suitable for the permaculture garden. What is the view? Is the garden private or open to the view of others? Are the plants and the environment itself beautiful?
- By introducing vegetation to roof tops, the hard edges and defined straight lines of the vertical boundaries of buildings, can be softened and made less absolute, which can therefore be seen to be a more calming and permissive environment.

*'The absolutely straight, dead skyline is an ignominious heirloom of the Bauhaus. If the boundary between the earth and the sky, as it were, the transition from man to God, is murdered by the ruler, all the bridges are broken down between man and a higher order.'*<sup>70</sup>

Hundertwasser 1985

- Light quality is made better with added vegetation by the reduction of cold hard shadows and glare from skyscrapers. The soft filtering of light through a canopy of vegetation may be reminiscent of light through a forest canopy.
- Sound in the garden may be a bit more difficult to control, though it has been proven that certain plants dampen certain sound frequencies.<sup>71</sup> With the added vegetation in the city,

<sup>67</sup>Venolia, Carol. 'Healing Environments' page 136

<sup>68</sup>This idea is discussed in the 'Benefits Universal to Roof Top Gardens' with a diagram.

<sup>69</sup>These could be eaten or used in a cup of hot water for a soothing tea.

<sup>70</sup>Hundertwasser, 'Hundertwasser Architecture: For a more human architecture in harmony with nature'

<sup>71</sup>Also, in the case of residents living near a motor way who complained of the incessant noise, a

birds may be encouraged back into the city which would be a pleasant noise in the garden and outside one's window.

- Other sound sources could be used to distract from street noises such as wind chimes, which would also give a direct sensory connection to the climatic phenomena of wind, again reinforcing connections back to the natural world.
- It may be desirable to create the feeling of privacy within the garden. This may help to make the place special by allowing the garden to develop its own peculiarities. The provision for privacy or private areas within the garden, may create a feeling of nurturing and caring. To create a feeling of privacy and refuge, edge plantings could be placed to block unpleasant views or frame views (of the sea or hills for example) to guide what the eye takes in. This could also block sight lines from neighbouring buildings or lower level pedestrians.
- It may be possible to create simple trellis or pergola type structures which create shaded areas in summer. In winter with the selection of deciduous vines, the same areas become open to the weaker winter sun. Such structures could provide the framework for multi purpose vines with functions such as pleasant scent, fruit, shade, insect food and habitat. These shading structures relate to the physical ease of the user of the garden but also could be used to design private areas.
- Different seasons can be considered so that colour and life exists in the garden all year round.
- If the roof top site was suitable, it may be possible to have a water feature in the garden. Water may have a soothing calming effect and is often seen to be related to cleansing of the spirit<sup>72</sup>. Incorporating water into the roof garden may also be used to grow food plants which grow in water, a way to employ methods of grey water reticulation, a rainwater collection point, irrigation, and a habitat for wildlife. An example of a water feature in a roof top garden is on roof of the Lotteries Commission Building on the corner of Vivian and Taranaki streets in Wellington.

There are huge lists of edible flowers and useful ornamental plants which have not been reproduced for the purposes of this report<sup>73</sup>.

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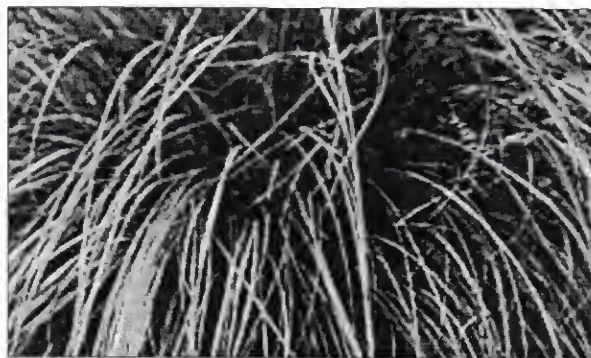
barrier of trees was planted which although did not change the actual level of noise much, may have been more a psychological help to remove the visual stimulus of the source of the noise.

<sup>72</sup>Beth Flinn 1999, also seen in many religions such as Paganism and Christianity with the Baptism ritual.

<sup>73</sup> An extensive list appears for example on page 17 - 18 of Graham Bell's 'The Permaculture Garden'



## ~Human Physical Health in the City Environment~



There could be numerable benefits for physical human health with the introduction of permaculture roof top gardens.

Increased numbers of roof gardens would mean more biomass within the city. This would increase oxygen levels in the air and decrease carbon dioxide levels from cars and other pollution sources. This would be particularly relevant for some of the main thoroughfare routes in the inner city of Wellington like Victoria Street and Vivian Street. According to Perry Davy's report called 'Monitoring of Carbon Monoxide at Vivian and Victoria streets, Wellington'<sup>74</sup>, 13 % of the time<sup>75</sup>, the air quality standard is 'completely unacceptable by national and international standards'<sup>76</sup>.

*'The results of this study show that the level of air pollutants from motor vehicles in the Te Aro area are attaining levels which may be of concern to human health. This should provide a trigger for action to improve the situation...'*<sup>77</sup>

Increased vegetation areas lessen dust and airborne particles in the air.<sup>78</sup>

In this section, the issue of gardens which may affect some people with allergies in a negative way has been addressed. This is looking at ways to design which incorporate low allergen plants.

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<sup>74</sup>This report was prepared for the Transport Policy and planning Department in September 1998.

<sup>75</sup>Using the 8 hour MAL, explained in the report

<sup>76</sup>Page 13

<sup>77</sup>Davy, Perry, 'Monitoring of Carbon Monoxide at Vivian and Victoria streets, Wellington', page 18

<sup>78</sup>Kuhn, Monica. 'Blooming Rooftops'. Permaculture International Journal Issue 63, June - August 1997.

### ~The Low Allergen Garden~

*'Unfortunately gardens are not kind to some people.  
Some of us are allergic to certain plants.  
Some of us find that our hay fever worsens when we go outside,  
our asthma flares up or our skin erupts.  
Some of us feel shocking at certain times of the year.  
We itch, sneeze, wheeze, bark and scratch.'*  
- Mark Ragg<sup>79</sup>

#### **Aim:**

To design a garden which performs the functions of a permaculture garden but with a focus on using plants that are low allergen.

#### **Who is this garden for?**

This garden is for those people that find certain plants aggravating. Basically these fall into two categories: Breathing allergies (such as asthma and hay fever) and skin allergies (such as eczema, and types of dermatitis). For the purpose of this design using the Municipal Building's unused terrace area, the garden would be aimed at the workers of the building that would use the space and the public who might visit it. One of the benefits of roof top gardens is that much of the air borne particles and pollen, which may be irritating to some, are above nose level of the general pedestrian.

#### **Elements to take into account when designing a low allergen garden:**

There seems to be a few basic things to avoid when designing a low allergen garden, due to the nature of possible irritants inherent in each case. These include:

- Close clipped hedges
- Open compost heap (closed systems such as a bin will help)
- 'Daisy' flowers
- Lawn
- Ornamental grass
- Wind pollinated trees
- Weeds of the nettle and plantain variety.

#### **Why should rooftops be used in this way?**

By taking into account the needs of people who experience uncomfortable allergies associated with plants, the garden becomes accessible for all. It is encouraging that most vegetables and fruits are low allergenic as well as many New Zealand natives because the method of reproduction is often not through pollen, but through birds. The inclusion of the provision for allergic people adds another facet to the permaculture garden

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<sup>79</sup> Ragg, Mark, 'The Low Allergy Garden', pg ix.

which is inherently one of all life, including  
inclusion and co-operation of sensitive humans.  
There are at least two excellent books<sup>80</sup> which would be helpful to consult if such a garden  
was to be designed:

*'The Low Allergen Garden'* by Mark Ragg  
Hodder Headline, New Zealand and Australia, 1996

*'Creating a Low Allergen Garden'* by Lucy Huntington  
Mitchell Beazley, London, Auckland, Melbourne, Singapore and Toronto, 1998

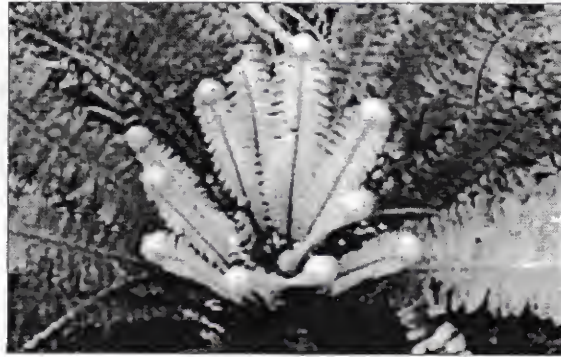
These books have comprehensive lists of which plants to avoid.

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<sup>80</sup>Available from the Wellington Public Library



## ~Re-generation and Habitat~



*'We did not inherit the earth from our ancestors ....  
we borrowed it from our children.'*<sup>81</sup>

Part of an extended permaculture system is the allowance for natural forest often as part of the 'zoning' system.<sup>82</sup> It may not be realistic to hope to re-create a natural forest system on our roof tops, but perhaps native species indigenous to Wellington could be selected where possible, to create a kind of native cloaking for the city, allowing this area to regain some of its original natural character.

Wellington used to be an area of lush coastal broad leaf / podocarp forest<sup>83</sup>, rich with bird life and other forest dwellers. The situation now is obviously very different, with virtually all of the original forest gone.

Local communities could be seen as ultimately responsible as kaitiaki of Aotearoa and more locally of Wellington for the preservation of their remaining native habitat areas, but also for the creation and nurturing of new areas of local flora.

*'It's easy for Wellington people to point the blame at others and forget that we destroyed 99% of Wellington's lowland rainforest and other natural habitats and eradicated a large variety of local species over the past 100 years. The Amazon present was our colonial past.'*<sup>84</sup>

-Wellington Branch of the Royal Forest & Bird Protection Society

This quote comes from a report that the Wellington Branch of the Royal Forest & Bird Protection Society put together called 'Natural Wellington'. It is a report that 'sets out a long term vision of the future of the natural treasures of Wellington'.

<sup>81</sup>First nation (American Indian) proverb

<sup>82</sup>This is a system of space organisation, often used in a larger permaculture development. For further information on such systems see Bill Mollison's 'Introduction to Permaculture'

<sup>83</sup>Dean Baigent - Mercer 1999

<sup>84</sup>Wellington Branch of the Royal Forest & Bird Protection Society, 'Natural Wellington', pg2

*'These forests teemed with bird and animal life. Birds were present at the rate of thousands per hectare and the dawn chorus would have been deafening. Keruru flocked in the kohekohe and miro trees. Tui, bellbirds and kokako chimed in the treetops. Saddlebacks and the mystical huia called in the bush. Whitehead, robins, tits and other small species flitted around on the forest floor and the mid canopy. Kaka and parakeets would have been abundant.'*<sup>85</sup>

The Forest and Bird report goes on to say:

*'Wellington would be an exceptionably beautiful rainforest city. The hills clothed in tall native bush with birds singing and playing in the canopy. A place of natural beauty for residents and visitors to enjoy. A wonderful natural complement to the city's vibrant cultural, business and recreational life.'*<sup>86</sup>

As well as the hills becoming alive again with the life of rainforest, perhaps some of the elements of the forest could be brought back into the heart of the city as well to create a canopy on the roofs of our buildings.

The best way to do this may be to plant as many natives as we sensibly can.

There are reserves in Wellington like Tapu te Ranga Marae, the Karori sanctuary and the Long Gully reserve and some groups like Manawa Karioi<sup>87</sup> are busy re-planting natives in and around the Wellington region. Here may be another opportunity to re-plant Wellington with its indigenous green cloak: above the city on the abundant space of some of the empty rooftops.

Following this section is a list of native plants that may be suitable for the roof top environment as well as a list of native birds that are found in the Wellington area or may possibly be encouraged back into Wellington city to give an idea of the species that may benefit from increased native gardens.

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<sup>85</sup>Wellington Branch of the Royal Forest & Bird Protection Society, 'Natural Wellington'.

<sup>86</sup>Wellington Branch of the Royal Forest & Bird Protection Society, 'Natural Wellington'

<sup>87</sup>Re-planting Tapu Te Ranga Marae in Island Bay

### ~A Native Garden Above the City~

*'Resist the inroads of foreign plant population and let our  
fast-vanishing trees and shrubs round which circle  
the legends and poetry of Maori and whose  
history is bound up with that of the solid land in which  
they grow, come back into their own, and take the  
foremost place which is their right'*<sup>88</sup>

- Dr Leonard Cockayne 1924

#### Aim:

To design a roof top garden which will grow native species, and will encourage animal life (mostly birds and insects) back to the city with the creation of habitat. This garden should be fairly maintenance free so human intervention is low.

#### Who is this garden for?

This garden is for the regeneration of native plant species. It allows an unutilised area to be used for the growing of some of the plants species which inhabited the space before it was occupied by human built structure. It is also a garden for wildlife. It would provide birds and insects with a habitat in the city and be a further building of 'green corridors', for birds especially, to get between bush habitat areas. A 'green corridor' allows birds to travel and access more habitat areas, keeping gene diversity at good levels. Many native birds will simply not fly over non-forested areas to reach nearby patches of bush.<sup>89</sup> With the continued shrinking of native forest and bush due to logging and more space created for human dwellings, and continued fragmentation of the forests due to more roading in particular, the area of habitat for birds becomes very limited. It is therefore important to provide pathways through human developments between major bush areas.

*'Another threat often disregarded is the isolation of ecosystems. Small patches of bush far from other bush areas cannot sustain bird life of any variety and over long periods of time will decline. Many native plants depend on birds to spread their seed and aid their reproduction. Lack of bird life is one reason for the very slow regeneration of local forest and the absence of certain plant species.'*<sup>90</sup>

Native species of plants will encourage native birds, insects and invertebrates back into the overall ecosystem of the city by giving them habitat, creating a more diverse, and therefore perhaps more stable ecosystem.

This garden also benefits people in two ways:

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<sup>88</sup> L.J. Metcalf, 'The Cultivation of New Zealand Trees' pg XI.

<sup>89</sup> Dean Baigent-Mercer. 1999

<sup>90</sup> Forest and Bird Wellington, 'Natural Wellington', pg 22.



By preserving native species on roof tops, plants and birds which were once part of the forest in New Zealand, and in fact Wellington, are encouraged to continue being an active part of the ecosystem to which humans also belong, creating a more diverse, stable and perhaps harmonious environment.

Mentally, people could be secure with the knowledge that we were part of a generation that did something positive about the environmental situation facing us at present.

*'And perhaps our children and grandchildren will appreciate the foresight of this generation who acted positively to hand it on to them in a better condition than they found it. Perhaps then we could look back and say we had achieved our mission.'*<sup>91</sup>

#### **Why should roof tops be used in this way?**

Most roof tops of course are not suitable for growing large native trees on due to the shallow soil profile.<sup>92</sup> They are however suitable for growing some of the smaller native species. Ferns<sup>93</sup>, a major feature of some of New Zealand's native forests, certain climbers which can function independently of large trees, native herbs, flax, and shallow rooting shrubs could be possibilities. Native epiphytes such as the astelia are adapted to growing up high in shallow soils in the forks of large trees, and may be another option. The humidity of the forest floor where some species grow may however not be an environment which can be re- created on roof tops.

Native plants are suited to the area's climate and soil type and often tend to be more hardy and less maintenance intensive than many exotic plantings. It may therefore seem logical to plant natives for inaccessible rooftops or ones where the area is seldom used. It may be better that seeds are eco-sourced and grown and nurtured locally before being planted out, so that good quality is assured and that the plants are used to the climate already. This seems to be in line with the unofficial policy of the Wellington City Council already<sup>94</sup>, to use native plants for city plantings where appropriate.

Larger species, not suitable for the roof top environment when mature, could be nurtured and grown on a rooftop and then planted out into other areas for re - generation.

Larger trees can be grown in large pots and strategically placed over structural supports of the roof below to distribute weight.

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<sup>91</sup> Forest and Bird Wellington, 'Natural Wellington', pg 22.

<sup>92</sup> Large native could perhaps be grown in some of the other suitable unused spaces in the city, such as vacant lots, and awkward spaces surrounding some buildings.

<sup>93</sup> Many ferns require the humidity levels found in a forest that may not be present on a roof top. There are suitable varieties however included in the 'Native Plant List'.

<sup>94</sup> 1998

### Native plant list suitable for the roof top environment

This list was compiled from information from the Landscape Architect Rebecca Wilson, and Dean Baigent-Mercer of Manawa Karioi and NFA. It is just a basic idea of some species to try and is not exhaustive.

Plants which are suitable will vary greatly depending on the microclimate of the site and whether the plants are grown in pots or in a larger area of garden.

\*indicates that parts of the plant may be edible or of medicinal use for humans according to Andrew Crowe's book 'Native Edible Plants of New Zealand'

#### Latin Name

#### Common Name

##### **Trees for rooftops**

Leptospermum spp.

Manuka

Kunzea ericoides\*

Kanuka

Olearia paniculata

Akiraho

(and other spp.)

Meryta sinclairii

Puka

##### **Trees - Bird Attracters**

Cordyline australis

Ti Kauka, Cabbage Tree

Cordyline kaspar

3 Kings Cabbage Tree

Pohutakawa\*(small cultivars)

Sophora microphylla

Kowhai, Stephens Island form

##### **Shrubs**

Aciphylla spp\*

Astelia: nervosa, chathamica

Brachyglottis: greyii, monroi

Carmichaelia spp

Hebe: speciosa, oporavar,

prostrata

Hibiscus trionum

Leptinella

Libertia: ixiodes, grandifolia

Linum monogynum

Myrsine divaricata

Pachystegia insignis

Marlborough rock daisy

Pittosporum cornifolium

Podocarpus nivalis\*

Mountain / Snow Totara

Pimelia: urvilliana, prostrata

##### **Shrubs - Bird Attracters**

Collospermum	
Coprosma repens*	Taupata
Corokia cotoneaster	
Griselinia lucida	Puka
Phormium: tenax, cookianum	Flax
Pseudopanax lessonii	
Xeronema callistemon	Poor Knights Lilly

#### Ground covers

Acaena: microphylla, enermis	Bidibidi
Coprosma acerosa*	Sand Dune Coprosma
Dispayma australe	
Myoporum debile	

#### Climbers

Clematis forsteri	
Metrosideros: perforata, carminia	

#### Climbers - Bird Attracters

Teocomanthe speciosa	
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#### Grasses

Carex: testacea, solandri	
Chionochloa: beddei, pallens, ruba	Narrow Leafed, Red and Silver Tussock
Rytidosperma viride	

#### Herbs(plants without woody stems)

Aciphylla: Montana, ferox	Shining Spleen Wort
Asplenium: terrestre, oblongifolium*	
Celmisia: mackauli, semidentata (also other suitable Clemisia)	Banks Peninsula daisy, Mountain daisy
Geranium traversii	Chatam Island Geranium
Myosotidium hortensis	Chatam Island Forget Me Not
Phymatosorus* diversifolius	Hounds Tongue Fern

#### Shady gardens

Asplenium: bulbiferum*, oblongifolium*, obtusatum	Shining Spleenwort Fern etc
Cordyline australis*	Ti Kauka, Cabbage Tree
Corokia spp	
Griselinia lucida	Puka
Myosotidium hortensis	Chatham Island Forget Me Not
Pallea rotundifolia	Button Fern
Phymatosorus diversifolius*	Hound's Tongue Fern
Rhopalostylis sapida	



**Additional native bird  
attractors<sup>95</sup>**

Coprosma: 'kirkii,' rhamnoides, robusta	Karamu
Fushia procumbens	
Melicytus crassifolius	
Myrsine australis	Mapou / Red Matipo
Pittosporum: crassifolium, tenuifolium, rigidum	Karo Kohuhu, Black Matipo Shrubby Kohuhu

**Native birds of Wellington city**

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<sup>95</sup>Source: Ell, Gordon 'Encouraging Birds in the New Zealand Garden'

Clare Mahney of the Wild life Service provided this list.<sup>96</sup>

Shining Cuckoo*	<i>Pipiwaharuroa</i>	Fantail*	<i>Piwakawaka</i>
Kingfisher	<i>Kotare</i>	Welcome swallow	
Morepork*	<i>Ruru</i>	Grey warbler*	<i>Riroriro</i>
Keruru *^		Tui*	
Silvereye*	<i>Tauhou</i>		
Harrier Hawk	<i>Kahu</i>		

\*Indicates forest birds still present in the Wellington area and native to New Zealand.

^only a few pairs left in Wellington 1998.

Forest and Bird in their 'Natural Wellington' Report stated that the following birds may be able to be attracted back to Wellington, or released if conditions were right:

Bellbird <sup>97</sup>	<i>Korimako</i>	Robin	Toutouwai
Kakariki	<i>Red crowned</i>	Long tailed cuckoo	<i>Koekoea</i>
	<i>parakeet</i>		
White head	<i>Popkatea</i>		

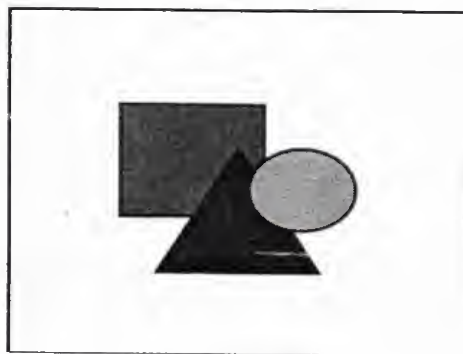


Figure 8: Keruru

<sup>96</sup> Ell, Gordon 'Encouraging Birds in the New Zealand Garden, pg 14

<sup>97</sup>There was a bellbird spotted in Wilton in early 1999; the first since the 1950's. -Forest & Bird Wellington Branch

## CHAPTER FOUR

### ~Technical Issues~

There are a number of technical issues to consider when designing a roof top garden. These are:

- Loading
- Water Proofing
- Roofing
- Drainage
- Microclimate
- Soil
- Construction
- Source of Materials
- Safety

#### Loading

The additional weight of soil, plants and the substrate need to be taken into account in terms of additional impact on the existing structural and carrying capacity of the roof and the rest of the building.

This should be checked with a structural engineer to confirm the extra weight that a roof can take. Buildings may not need to be structurally modified with careful choosing of materials and plants appropriate to the load carrying capacity of the roof.

Heavy or large planted areas or plants in large pots can be placed over bearing walls or columns to distribute weight.

Here it is worth noting that 'green' roofs can obviously be divided into two categories: The inaccessible, vegetation covered roof and the roof garden with the possibility of human access which is the focus for this report.

The former are often referred to as eco-roofs, green roofs, or extensive roof gardens (as opposed to intensive roof gardens), and typically cover the whole roof with a continuous thin growing medium that supports low vegetation. There is minimal additional loading due to the lightweight growing median and such vegetation covers are not confined to flat surfaces. Roofs with a slope of up to thirty degrees can be 'greened' if provided with a raised grid structure to hold the soil in place<sup>98</sup>. These kinds of roof gardens have been well tested in Germany for many years. Some cities in Germany require green roofs on flat roofed buildings. In 1989 one million square metres of green roof gardens were under construction in Germany.<sup>99</sup> These kind of roofs which have the same environmental benefits as larger, deeper profiled roof top gardens and generally are no or low maintenance, may be a good option for those buildings with inaccessible roof tops or low additional loading capacities.

30 cubic centimetres of wet earth weighs about 45 kg.<sup>100</sup> It is important to remember however that 'earth' is not the 'soil' that would be on a roof top. It would have added

<sup>98</sup>Thompson, William. J. 'Grass Roofs Movement'. Landscape Architecture, May 1998 page 47

<sup>99</sup>Thompson, William. J. 'Grass Roofs Movement'. Landscape Architecture, May 1998 page 48

<sup>100</sup> Kuhn, Monica 'Blooming Rooftops'. Permaculture International Journal Issue 63 1997 page 25



compost, mulch and fillers which would decrease the weight. Not all planting beds have to be at a uniform depth either, which shallower rooting plants requiring obviously less soil profile depth and therefore less loading.

'Mounding' means that the soil is heaped up around areas supporting trees so that the whole soil profile is not at the same deeper level. This minimises loads on the existing structure. This mounding must be gradual because roots may tend to surface round the edges of a mound as the tree gets larger. The other option is simply to use large containers to grow the larger trees if they are desired. Large ceramic containers are suitable as well as many unused containers that could be appropriated for the task of growing plants. An example of this is seen on the roof top of the Lotteries Commission building on the corner of Cambridge terrace and Vivian Street, in Wellington where a larger Pohutakawa tree has been grown in a container separate to the planted garden space. This relatively shallow area does however support two large Kowhai shrubs and two or three Kowhai seedlings are on the way too.

### **Water Proofing**

The roof top must be completely water proof (as surely all good roofs are) before a garden could be constructed. The issue of strict detailing to ensure complete water tightness applies mainly to buildings being built specifically with a roof top garden as part of the design. For existing buildings the tanking should already be in place, but if necessary elastometric coatings such as a rubber membrane can be applied to prevent leaks. Drains, joints, edges and seams in the existing membrane should be carefully examined. The water-proofing layer must be protected from invasive roots or over enthusiastic gardeners with sharp tools<sup>101</sup>.

### **Roofing**

The state of the existing roofing must be assessed. Drainage points must be noted and the membrane must be looked at to ascertain weather or not root penetration could occur. With the correct use of filter layers and / or root penetration protection layers, this problem should be eliminated. Life of the actual roof membrane must also be considered; could it be replaced or repaired at a later date without disrupting the established garden? The addition of a roof garden does in fact lengthen the life of a roof because it forms a protective layer against UV rays and lessens the effects of thermal temperature swings.

### **Drainage**

Careful design of drainage detailing is important in rooftop gardens. It is very important to ensure that no organic matter is able to get into the drains and clog them. An open drainage layer and a filter cloth beneath the soil is usually adequate and allows water to drain through normal channels if the roof garden is added to an existing building. Some sources recommend gravel guards at the head of all downpipes less than 200 mm in diameter to form a second defence against loose material<sup>102</sup>. They also protect the pipes during construction.

### **Microclimate**

The specific microclimate of the roof itself must be considered. Gardening on the roof is quite different from on the ground. It can be much more sunny and dry, and more windy. This would be particularly relevant to the inner city where the tall buildings form wind tunnels and tend to shade the streets below. Wind speeds are difficult to predict due to crowding and over

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<sup>101</sup>One advantage of permaculture is that there is often little or no disturbance to the soil due to no dig and mulching methods.

<sup>102</sup>Scrivens, Stephen. 'Landscape Update 3 Urban Planting', AJ 15 February 1989, pg 64

shadowing by buildings at roof top level.

Temperature swings may be more extreme. The shallower soil profiles also mean that the soil has the potential to dry out much more quickly.

A way to regulate this is by using mulch<sup>103</sup>. If ground cover plants are used rather than bare soil left exposed to the sun, soil will not dry out due to evaporation as quickly. An established ground cover will also stop wind erosion of the soil. Using plants which are suitable to such conditions is obviously advisable, and shade structures and trellises can also be utilised. Rainwater can be collected to use for the dryer days as well as irrigation systems used.

If we again look at the municipal building example site, rainwater could easily be collected from the down spouts in the corners.

Light should be considered. If a plant is placed right next to a wall, growth on the wall facing side may be stunted and one sided because of the lack of sunlight on this side. Light levels on a roof top are however generally better than at street level, so the effects may be less extreme<sup>104</sup>.

Plants may not receive the water they need if placed under an overhang. Many people think that moisture can travel sideways in soil but this movement is very limited.<sup>105</sup> To combat this, irrigation or hand watering of the sheltered areas may be necessary.

### Soil

There is much information available about soil and how it should be transported and placed, to avoid nutrient loss. There are a lot of products on the market which can be added to soils to help with anchorage, moisture retention and soil structure, however these may be beneficial but they may not be necessary, if appropriate plants and combinations are used to do the same jobs, or if species are planted to encourage insects which perform necessary functions, such as what generally happens in the permaculture environment.

One of the most important functions of soil depth is to act as an anchor for the roots of larger plants against wind. With the shallower soil profiles available in roof top gardens, the problem of inadequate anchorage may be solved by the guying of roots to underground baulks of timber called 'dead men'<sup>106</sup> or more simply by having a grid of heavy steel mesh placed below the soil where roots can 'grab on to it'<sup>107</sup>. This may only be necessary for large trees, because larger shrubs and smaller plants generally don't require such depth for anchorage.

Quite surprisingly larger trees can be grown in relatively shallow soil depths as an extract from Stephen Scriven's article in the February issue of AJ 1989 entitled 'Landscape Update 3 Urban Planting' shows:

*'Taproots are a frequent cause of unnecessary concern. Different species of trees tend*

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<sup>103</sup> Some common mulches are bark (should be shredded and fibrous), straw, forest litter, shredded paper, synthetic sheets, grass clippings, sea weed etc.

<sup>104</sup> Scrivens, Stephen. 'Landscape Update 3 Urban Planting', AJ 15 February 1989, pg 60

<sup>105</sup> Scrivens, Stephen. 'Landscape Update 3 Urban Planting'. AJ 15 February 1989.

<sup>106</sup> Scrivens, Stephen. 'Landscape Update 3 Urban Planting'. AJ 15 February 1989.

<sup>107</sup> Hitchmough, James, 'Calculating the Earth' Landscape Design, September 1992.



*to exploit distinct horizontal zones for rooting. Most nutrients are to be found naturally in topsoil which is seldom more than 300 - 400 mm thick and frequently much less. While many plants have taproots when small, it is doubtful whether they have any effect after the first few years. And modern nursery practice is to undercut roots or young trees to encourage the formation of a fibrous root system.*

*Large trees growing in deep soil can develop a root mass down to 3m. But given that root spread is likely to be of the same order of radius as the height, the deepest roots do not significantly affect the total. Thus, although most plants will exploit deep soil, this is not necessary to allow most species to flourish. The lush planting of Gateway House's roof garden at Basingstoke shows what can be done with 300mm of topsoil over layering a 50 mm drainage layer, mounded to some extent for trees.*<sup>108</sup>

Many information articles on roof top gardening give conventionally accepted soil depths which generally are the following:

- 150-300mm for turf, herbs and ground covers
- 450- 600mm for shrubs
- 800mm or more for trees.

There are more complex ways of determining the necessary depths based on calculating the whole plant's daily water use and the adequate soil volume to support the canopy volume, giving a necessary 'cubic metres of unsaturated soil', rather than a more simple depth measurement. This method is detailed in an article by James Hitchmough called 'Calculating the Earth' appearing in the September issue of Landscape Design 1992.

### **Construction**

There are many ways to construct roof top gardens and it would be advisable to consult a person who thoroughly knew what would be appropriate for each site.

Basically, a general cross section for a roof top garden would be something along the lines of the following:

- The roofing membrane and waterproofing layer.
- A layer for prevention of root penetration
- A drainage course of gravel or something similar to allow for water to drain from the roof in the original way
- A filter cloth layer to prevent soil, growing median or organic matter from clogging the drainage layer and to prevent root penetration
- The growing median layer (sometimes called the planting substrate layer) which is essentially soil.
- And of course the plants.

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<sup>108</sup>Page 59 - 67



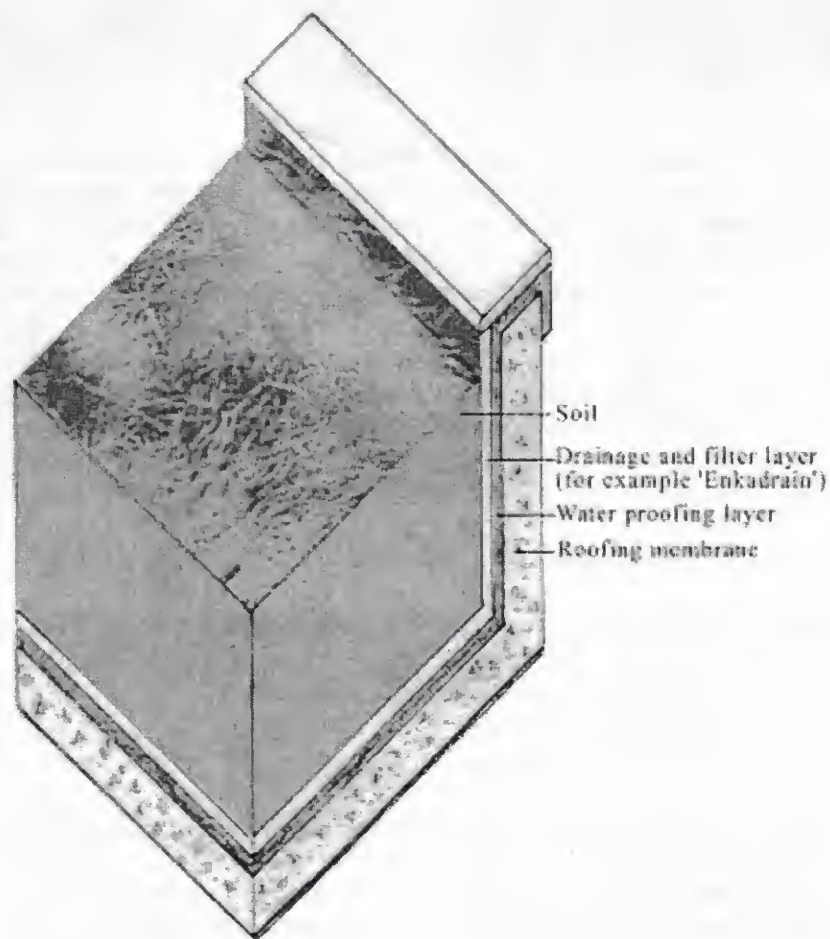


Figure 9: Construction Detail.

#### Waterproofing Layer

There are number of different materials used for the waterproofing and final root protection layer that are found in various examples.<sup>109</sup> Mastic asphalt, elasotometric bitumen, and EPDM are examples<sup>110</sup>.

#### Water Proofing Protection Layer

There are many possibilities for this layer depending on the nature of the site. Examples are paving slabs, or a 50 mm sand/cement screed with sealing paint to stop lime from the screed being picked up in drainage water and blocking drains with scale<sup>111</sup> or an additional rigid insulation layer, which is the lightest option and may also have considerable internal comfort and energy benefit in the building. An example of rigid insulation is polystyrene sheet.<sup>112</sup>

#### Drainage Layer

There are a number of different materials this layer can consist of and therefore the depth of this layer also varies. A clean light aggregate could be used.

<sup>109</sup> Scrivens, Stephen. 'Landscape Update 3 Urban Planting', AJ 15 February 1989 page 64

<sup>110</sup> See the Greener Building Directory on the internet – compiled and researched by Victoria University.

<sup>111</sup> Scrivens, Stephen. 'Landscape Update 3 Urban Planting', AJ 15 February 1989 page 65

<sup>112</sup> Use of artificial materials and the impact they have on the environment should be considered.

A number of the landscape architects in the Wellington region recommended the use of synthetic drainage layers, which are lighter and can be as effective as the thicker aggregate layers at greatly minimised thicknesses, and therefore loading weights. It may be worth investigating the production process and disposal of such materials in relation to pollution problems<sup>113</sup>.

#### Filter Layer

The layer separating the drainage and soil layers was traditionally a 50mm glass-fibre matt, compressed by the soil layer to only a few millimetres thick. Newer, perhaps more suitable products are polypropylene and polyethene geotextile fabrics which combine considerable strength with good filtering properties.

#### Soil Layer

It is suitable to use a nutrient rich soil with is locally available and made of natural organic materials.

#### Construction Example

The following image is of St Mary's Colombo St roof and semi roof garden in Christchurch<sup>114</sup>. The image shows soil being laid over S8004 / 2 Enkadrain<sup>115</sup>, which is over an impermeable liner. 'Megaflo'<sup>116</sup> panel drain is placed under boxing (bottom right of image). Over 600 m of Enkadrain was used and 100 m Megaflo was used. The consultant was Peter Rough Landscape Architect from Christchurch.



Figure 10: St Marys roof garden in Colombo Street, Christchurch, New Zealand during construction.

<sup>113</sup> See the Greener Building Directory on the internet – compiled and researched by Victoria University.

<sup>114</sup> Image and information supplied by Tony Lingley, Southern Area Manager, Maccaferri NZ Ltd.

<sup>115</sup> S8004 / 2 is the name given to the New Zealand stock item number of Enkadrain.

<sup>116</sup> 'Megaflo' is 'a high strength high flow panel drain available in a wide range of sizes each with its own range of fittings' - from the 'Megaflo The Complete Drainage System' brochure from Geofabrics Australasia Pty Ltd. Also supplied by Maccaferri.

#### Source of the Materials

There are two companies which are currently utilising the organic waste from the two Wellington landfills. 'Green Cycle Ltd'<sup>117</sup> operating out of the Grenada North landfill and 'Living Earth'<sup>118</sup> which works from the Southern landfill, where the sewage or 'bio - solids' from Moa point are also being used to make types of compost. The sewage component, which is relatively new is on trial at the moment by the Botanical Gardens and possible soon at the Berhampore nursery where the city council sources all of the plants for city plantings already. Both people talked to from the companies were keen to become involved with providing the soil for roof top gardens and it seems the necessary links between them and the Wellington City Council already exist.

Both of these companies offer a range of suitable products that are weed free and could be used on roof tops. What a great way to close the loop on city waste recycling by letting gardens flourish above our sky line, feed by 'waste'.

As far as a source of plants go there a number of different options. Any normal outlet would do for small scale plantings. Plants could also be grown from bought or collected seeds on the actual roof top or in a protected environment such as indoors.

#### Safety

Issues such as how the roof is accessed, how materials get onto the roof and who uses the area need to be considered. The addition of safety rails or raising of existing ones may need to happen before humans can occupy the space.

If we again take the council rooftop as an example, access would stay the same, that is through the adjoining office space. Railings are already in place but may need to be raised slightly to meet requirements of the building code. Materials to construct the garden could be brought up lifts and materials could be ferried up over a period of time during after hours time or in the weekends (the size of the lift and the dimensions of things that need to go up must be thought about). A crane could perhaps lift the materials up in one go from civic square, or more simple pulley or conveyor belts methods could be used.

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<sup>117</sup> Phone (04) 4784311

<sup>118</sup> Phone 0800 compost  
0800 2667678



## CHAPTER FIVE

### ~Maintenance~

*'The permaculture garden must be highly productive but require  
as little work as possible'<sup>119</sup>*  
- Graham Bell

Knowing how to design low maintenance gardens is obviously very beneficial when talking about how inner city gardens would be maintained and by whom. The ways to minimise effort for maximum enjoyment and yield output are thoroughly discussed in the section 'Beginning the Permaculture Design'.

No garden is of course totally maintenance free and so the question comes up: Who will look after these gardens?

There are a number of different ways this issue can be addressed:

- Personal private gardens could be looked after by the residents of the building.
- Volunteers supported by the task force green scheme for example or similar schemes could maintain public areas. 'Volunteers' may also be able to be paid in produce from the garden.
- For gardens on the 'property' of private companies, similar people could help maintain the gardens as an incentive for these companies to allow roof gardens on their unutilised space. This could work well because it wouldn't cost the company anything but they would receive the many benefits already discussed in the earlier sections. Alternatively workers could be paid with a wage from the actual company.
- The 'Green Dollars'<sup>120</sup> scheme which is already working in Wellington through the 'People's Resource Centre' could provide workers to tend the garden on a kind of bartering system. Similar systems may also be appropriate.
- The implementation of roof gardens could create part time jobs for many people or full time jobs for those that work in more than one garden. This is surely a positive aspect, with WINZ<sup>121</sup> advocating the positive mental and financial aspects of employment for those that are unemployed.

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<sup>119</sup>Bell, Graham. 'The Permaculture Garden' page 63

<sup>120</sup>For more information on this system there is a brochure available from the People's Resource Centre.

<sup>121</sup>WINZ stands for Work and Income New Zealand.

## ~Conclusion~

Permaculture is an exciting possibility for cities and may help to solve some of the current and perhaps future problems associated with the condition of the modern city. Permaculture with its many different approaches to creating garden areas and living environments, has been shown to offer significant benefits to a city and may be especially suited to achieving the aims of sustainable development in cities. The methods and principals involved in permaculture design can be applied to any climate or location, taking into account permaculture's careful way of observing the microclimate of a specific site, to create a design which works harmoniously with the existing site conditions.

Roof top permaculture in an inner city context has been thoroughly explored here, and it can be seen that many of the same ideas could easily be applied to other, neglected, unutilised spaces that exists in almost any city. The potential only has to be seen and the support given for people to transform these 'wasted' areas into productive, beautiful spaces which are able to make a positive contribution to the city.

The question may well be asked: Where can we go to from here? The author is of the opinion that permaculture, and roof top permaculture as an aspect of this, should be encouraged and explored further by practical research. Smaller experimental designs could become examples for a city, and a city adopting more permaculture design for their urban environment would in turn become an example for other cities to follow.

In light of this, a submission for the encouragement and implementation of inner city permaculture for Wellington<sup>122</sup>, New Zealand, has been written as a smaller more focussed document using the information contained in this report, put into the context of Wellington city in New Zealand Aotearoa. Similar ideas could be applied to other cities.

With the support of local governing bodies and community groups, cities can be transformed into more productive, nurturing environments attuned with ideas of sustainability, co - operation, well being and caring for the earth as a positive vision for the future.

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<sup>122</sup>This is written by the same author as this report and is available on this web site or by contacting the author

Email: maibrittpedersen@yahoo.com

### ~Picture Credits~

- Figure 1** : Example site seen from Civic Square, Wellington, New Zealand.  
(Photo - Maibritt Pedersen)
- Figure 2** : Existing roof top site, - note drain pipe in corner.  
(Photo - Maibritt Pedersen)
- Figure 3** : Elements of a total permaculture design.  
(From 'Introduction to Permaculture'. Bill Mollison. Page 2)
- Figure 4** : Examples of ways to increase edge lengths.  
(Drawing - Maibritt Pedersen)
- Figure 5** : Increasing the growing plane area  
(Drawing - Maibritt Pedersen)
- Figure 6** : Plant stacking in a rich soil and water environment, sharing light and nutrients in canopy, mid level, and herb strata.  
(From 'Introduction to Permaculture'. Bill Mollison. Page 21)
- Figure 7** : Relationship networks in the garden.  
(From 'The Permaculture Garden'. Graham Bell. Page 31)
- Figure 8** : Keruru – Wood Pidgeon  
(From 'New Zealand's Native Birds of Bush and Countryside.' Penguin Pocket Guide.)
- Figure 9** : Axonometric section of a roof garden detail.  
(Drawing - Maibritt Pedersen)
- Figure 10** : St Mary's roof garden in Colombo Street, Christchurch, New Zealand during construction  
(Photo from Tony Lingley, Maccaferri NZ Ltd)

All other photos and images except the cover image are by Maibritt Pedersen.



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